Development of a CO2neutral hybrid street lighting system for the Danish municipalities' illumination classes

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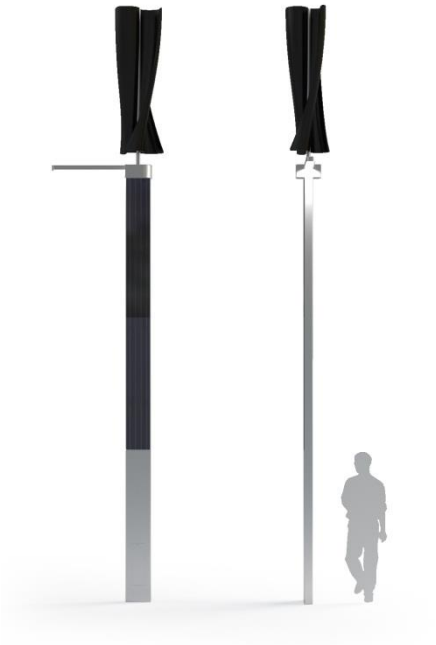
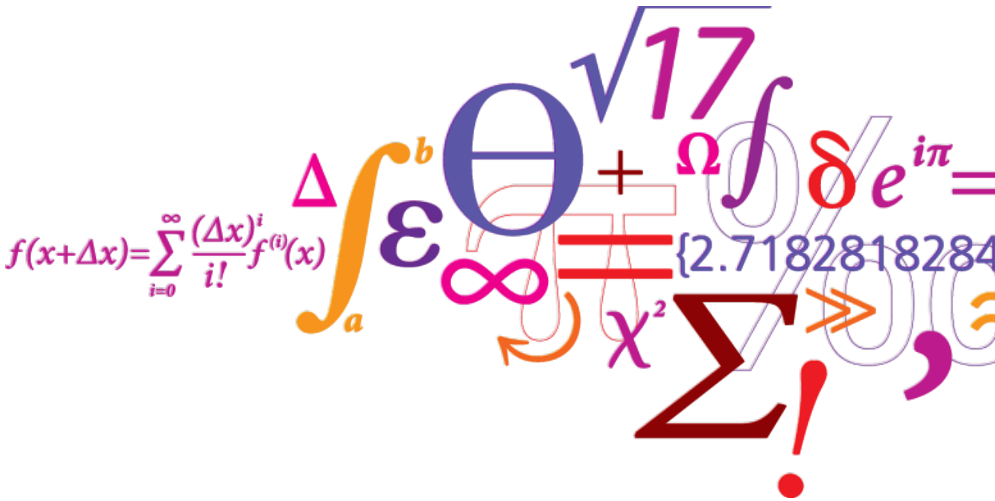
ELFORSK PSO 343-021





Peter Behrensdorff Poulsen, Project Manager, DTU Fotonik

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Department of Wind Energy

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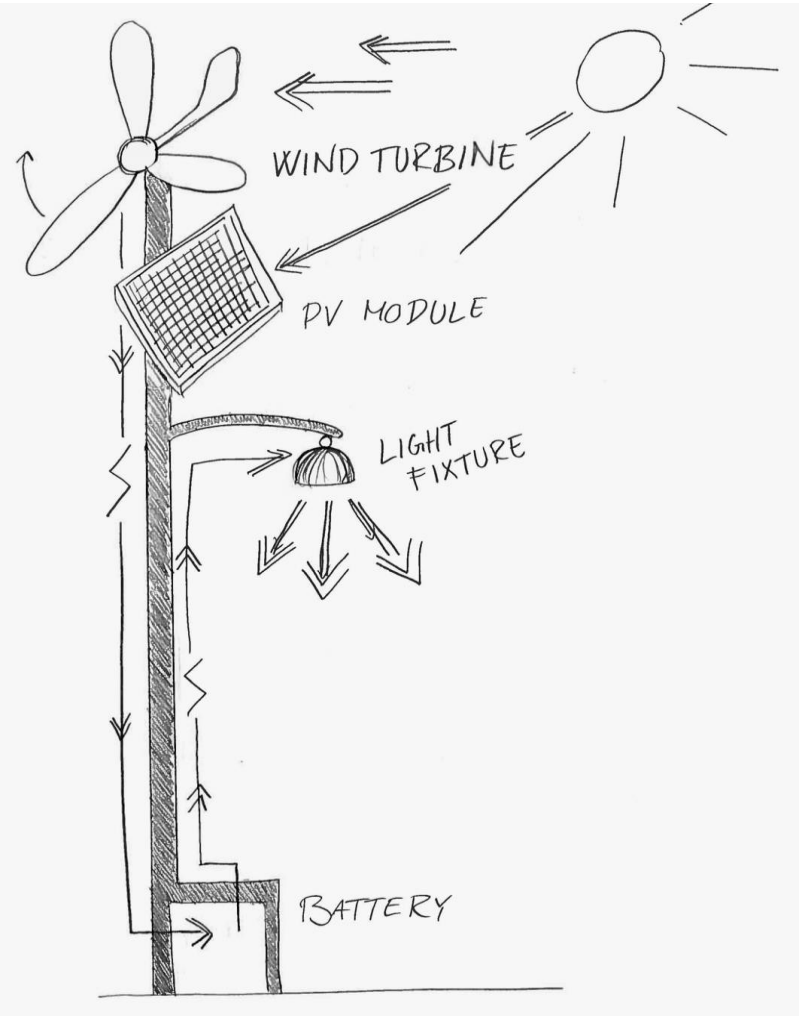
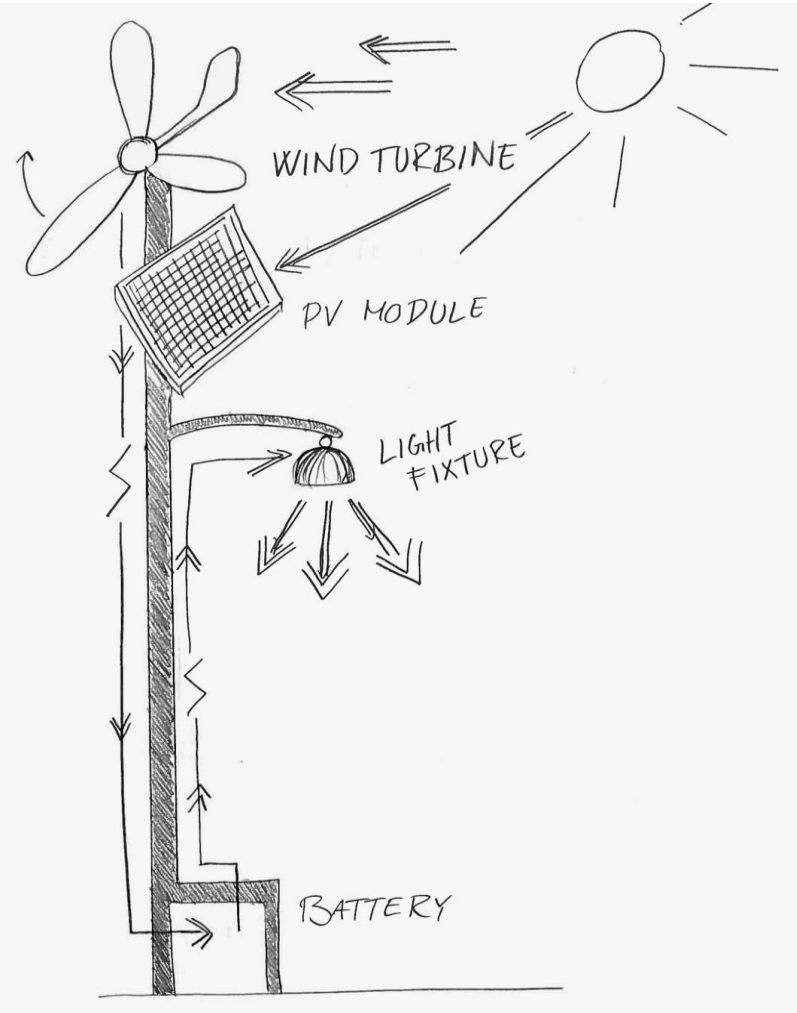
What is a hybrid system?



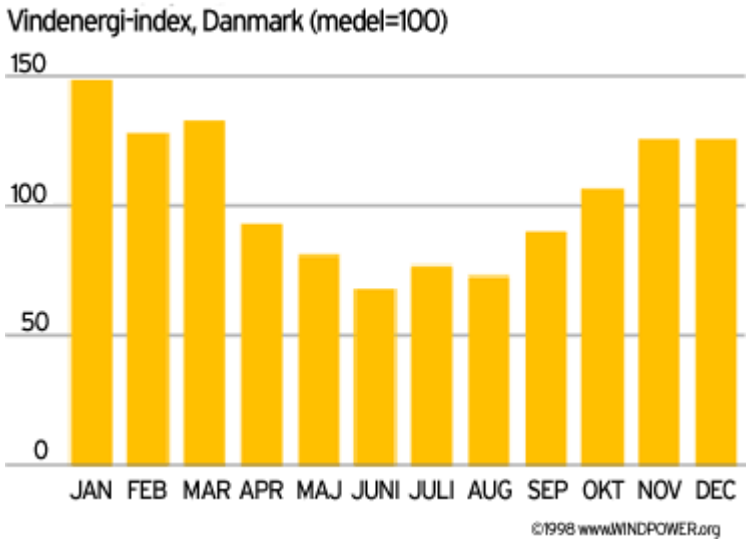
Vision

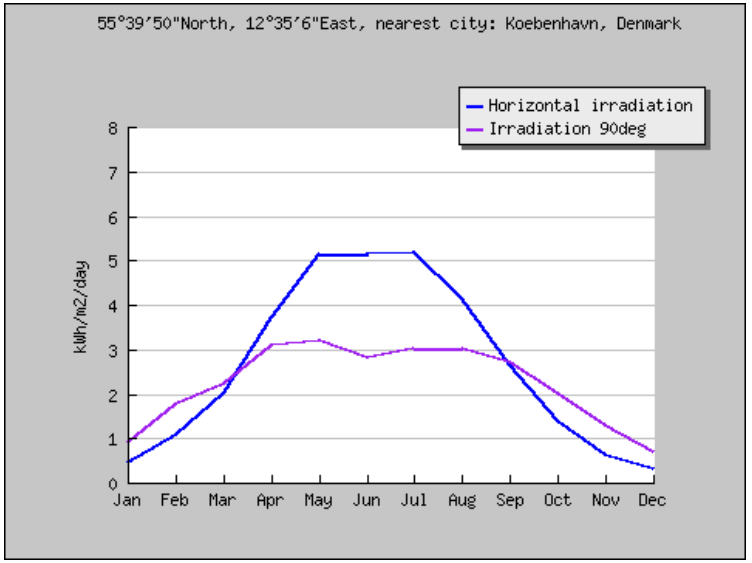
1. Can a hybrid system be developed full filling the needs of the Danish Municipalities?
2. Is there a business model?

- Stand alone solution
  - Installation, pole, luminaire = free
  - No cabling
  - Free energy
  - Wind turbine, solar panel, battery



Wind and solar energy in Denmark





October 3rd 2013

Society driven innovation

Internationally leading research

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  Department of Wind Energy
- **DTU Electrical Engineering**
  Department of Electrical Engineering
- **DTU Fotonik**
  Department of Photonics Engineering

Producers

PHILIPS sense and simplicity

PRIESS

Sweet spot

Users

GATE 21 SUSTAINABLE FUTURE FORUM

KØBENHAVNS KOMMUNE

Albertslund Kommune

Egedal Kommune

Specialists

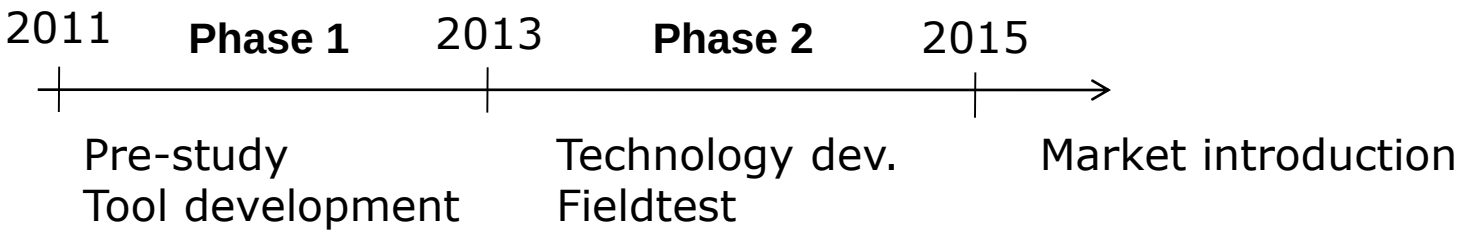
HENNINGLARSEN ARCHITECTS

faktor 3

DONG energy

Project contents

- ✓ **Market Screening**
  - ✓ Which solutions exists
  - ✓ Test and characterize a selection
- ✓ **Develop Mathematical model**
  - ✓ Dimensioning of the system
  - ✓ Validation using measurements on commercial systems
- ✓ **Mapping the potential energy as a function of street lighting class**
- ✓ **Select street lighting class for the design process**
- ✓ **Lab model**
- ✓ **Mock up**
- ✓ **Renderings**



Screening of hybrid system market

- 29 hybrid systems identified (January 1st 2012)
- Official document
  - Director Center for Traffic CPH
  - Price
  - Delivery time
  - Data sheets
- Suppliers
  - Primarily in China (some with EU sales office)
  - 2 USA
  - 2 Canada
  - 2 Korea
  - 1 France

Primarily wind turbine suppliers

Copenhagen January 24th 2012

To suppliers of hybrid street lighting solutions

The capital of Denmark, Copenhagen Municipality is facing a major challenge with its ambition of being CO2 neutral by 2025. Large renovations of street lighting systems will go on in the next few years and this field is therefore on target for special attention, due to the opportunity for realizing large energy saving potentials that new technologies offer, such as LED, solar cells and perhaps small wind turbines when integrated into street lighting.

Denmark has due to its location to the north special challenges due to long and dark winters with very low potential for solar cell energy creation and a high need for lighting due to long dark periods. These periods are though very windy and wind turbine solution seems obvious. The summer period are almost without wind but very sunny due to the very long days and short night time and a solar panel solution is perfect for this period. So to fit the weather conditions in Denmark a CO2 neutral solution for the urban environment seems to be a hybrid solution based on LED, solar panels and wind power technologies.

Since the energy saving need is the same for all the municipalities in Denmark which shall be independent of fossil fuels by 2050, Copenhagen Municipality has teamed up with the Technical University of Denmark to find the perfect hybrid street lighting solutions on the market suitable for fulfilling the lighting requirements in Denmark.

The Technical University of Denmark will in first half of 2012 be obtaining and testing relevant hybrid street lighting solutions under Danish conditions. In order to prepare a recommendation for the Danish municipalities, we are requesting technical specifications, data and prices from suppliers.

We hope that you can help.

Sincerely

Niels Tørslev
Center Manager

CITY OF COPENHAGEN
Technical and Environmental Administration
Centre for Traffic

Risø DTU
National Laboratory for Sustainable Energy

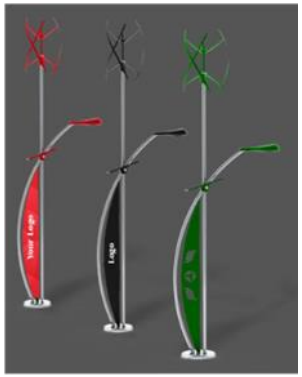
DTU Fotonik
Department of Photonics Engineering

4 commercial systems was chosen

- Delivery time
- Rotor types
- Specifications
- Different distributors
- Different parts of the world

China Green Power

United Electricity



Sanya

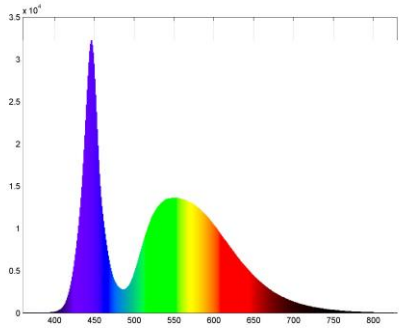
Nheolis


11:15 22/MAY/2012

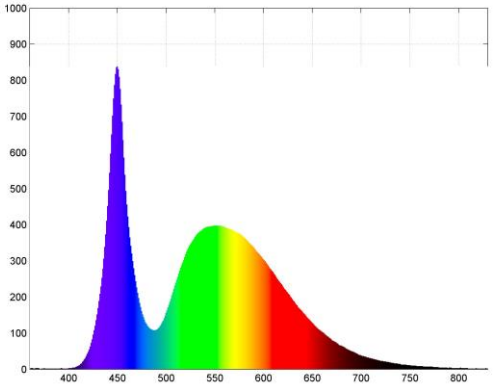

11:06 19/JUN/2012


DTU

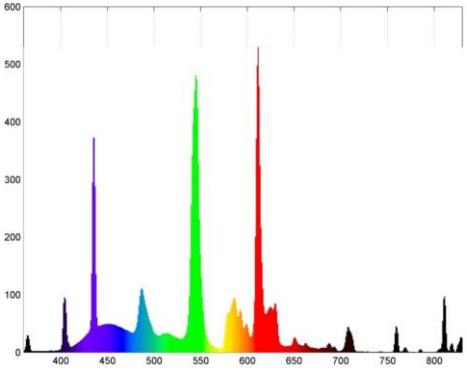
Nheolis



China Green Power

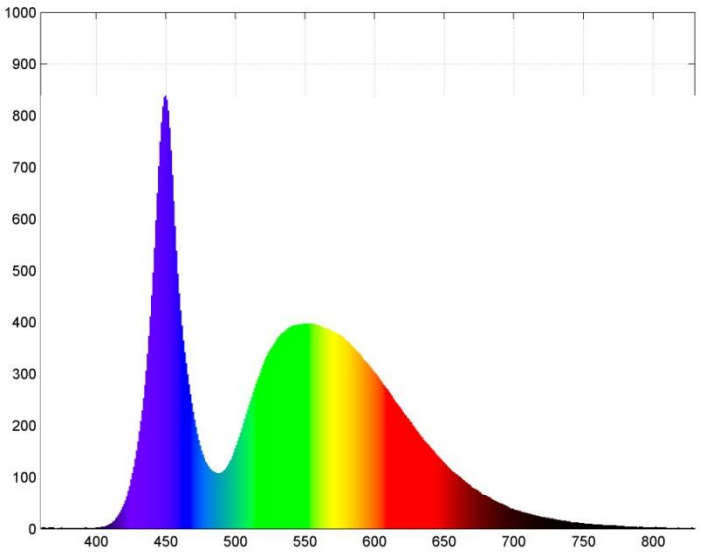


United Electricity



Lamp	Effekt forbrug	Color Rendering	Correlated Color Temperature	Duv
Neohybrid	60 W	73.0	7202	0.0073 (false)
China Green power	61.5 W	74.4	6663	0.0010 (true)
United Electricity		83.2	4693	0.0041 (true)

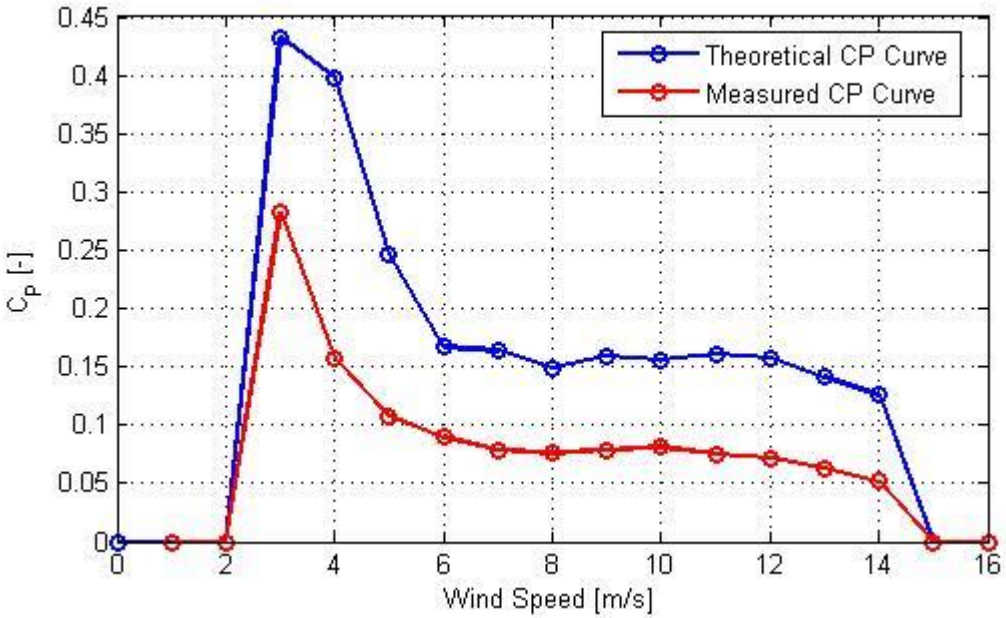
Sanya



About 6600 K

Wind turbine power curves

- Average wind speed in the urban environment: 1,5 m/s
- Challenges in turbine design and generator design



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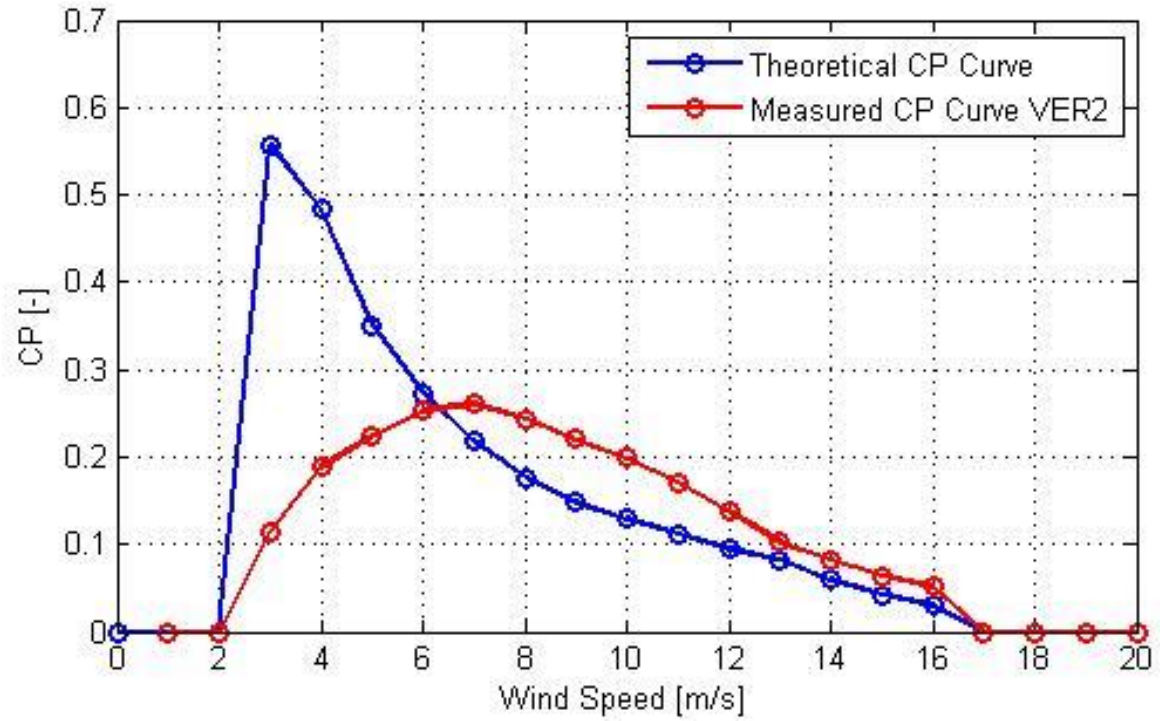
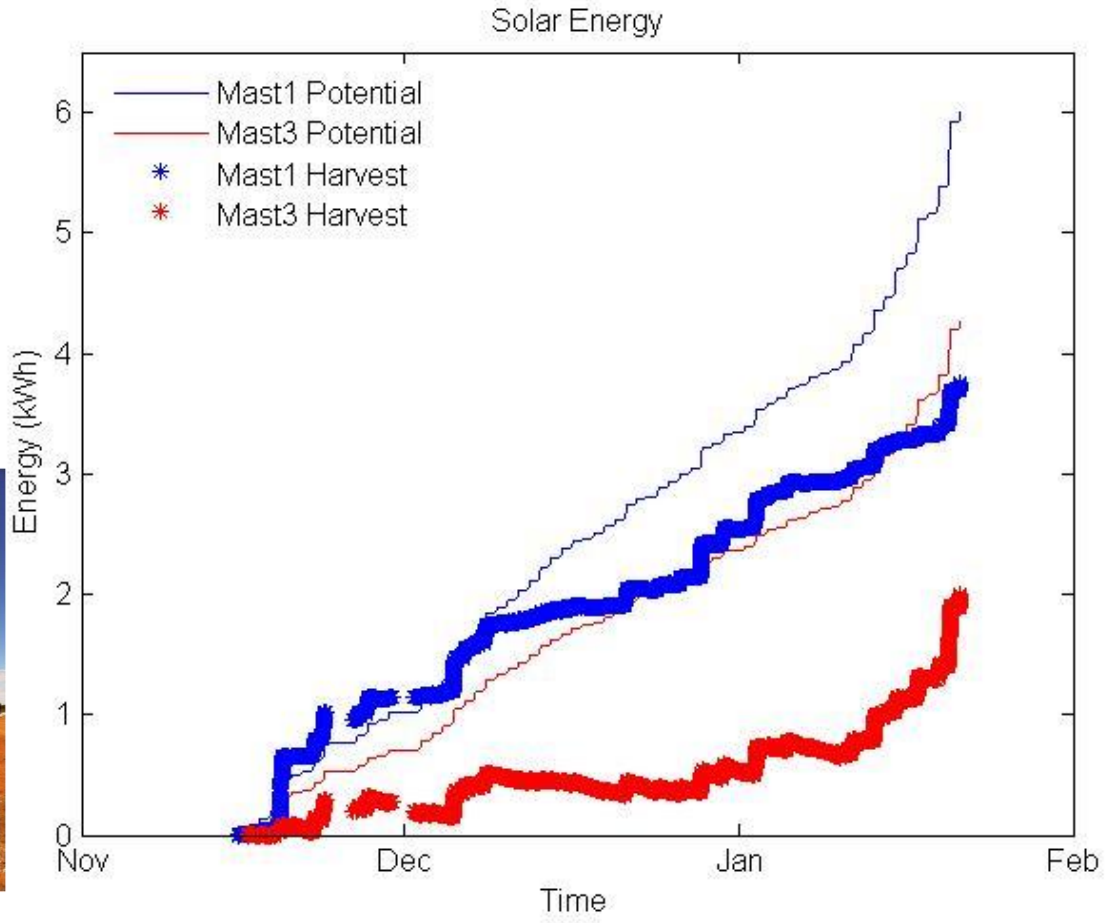


Solar panels

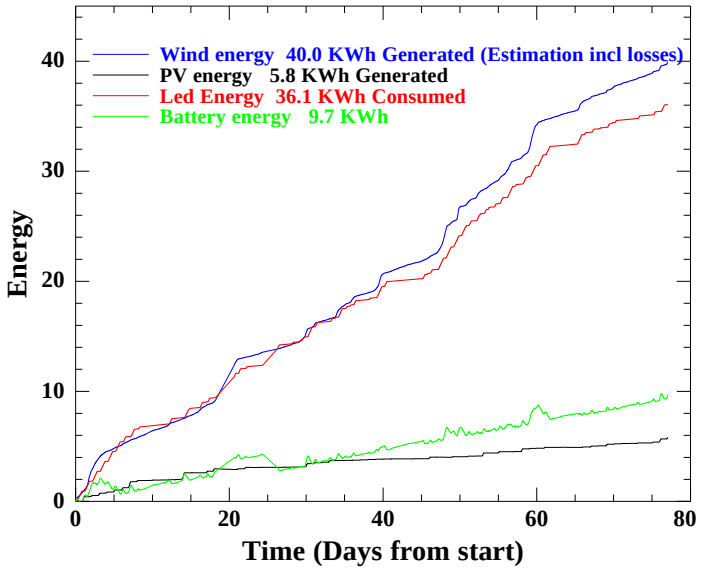


Batteries

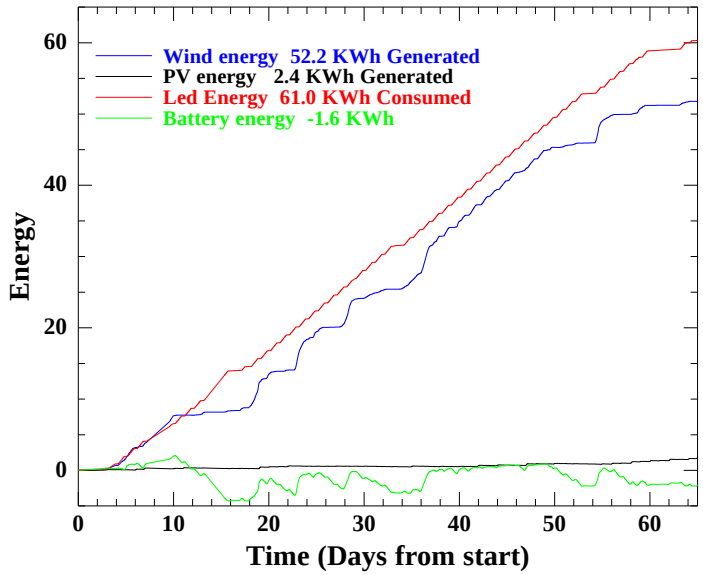
- Very cheap lead acid batteries
- 1 VRLA battery
- Short life time

Energy balance

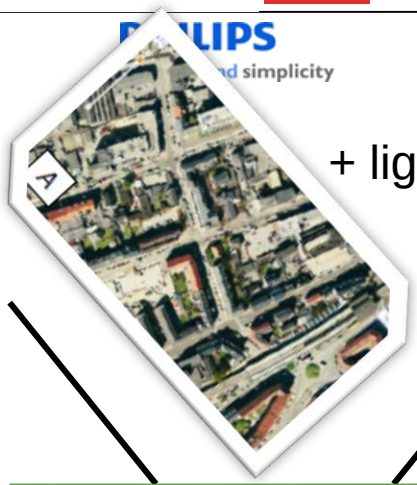
Mast 1



Mast 3



Mathematical model



+ lighting requirement+ GPS coordinates

Solar data

Wind data

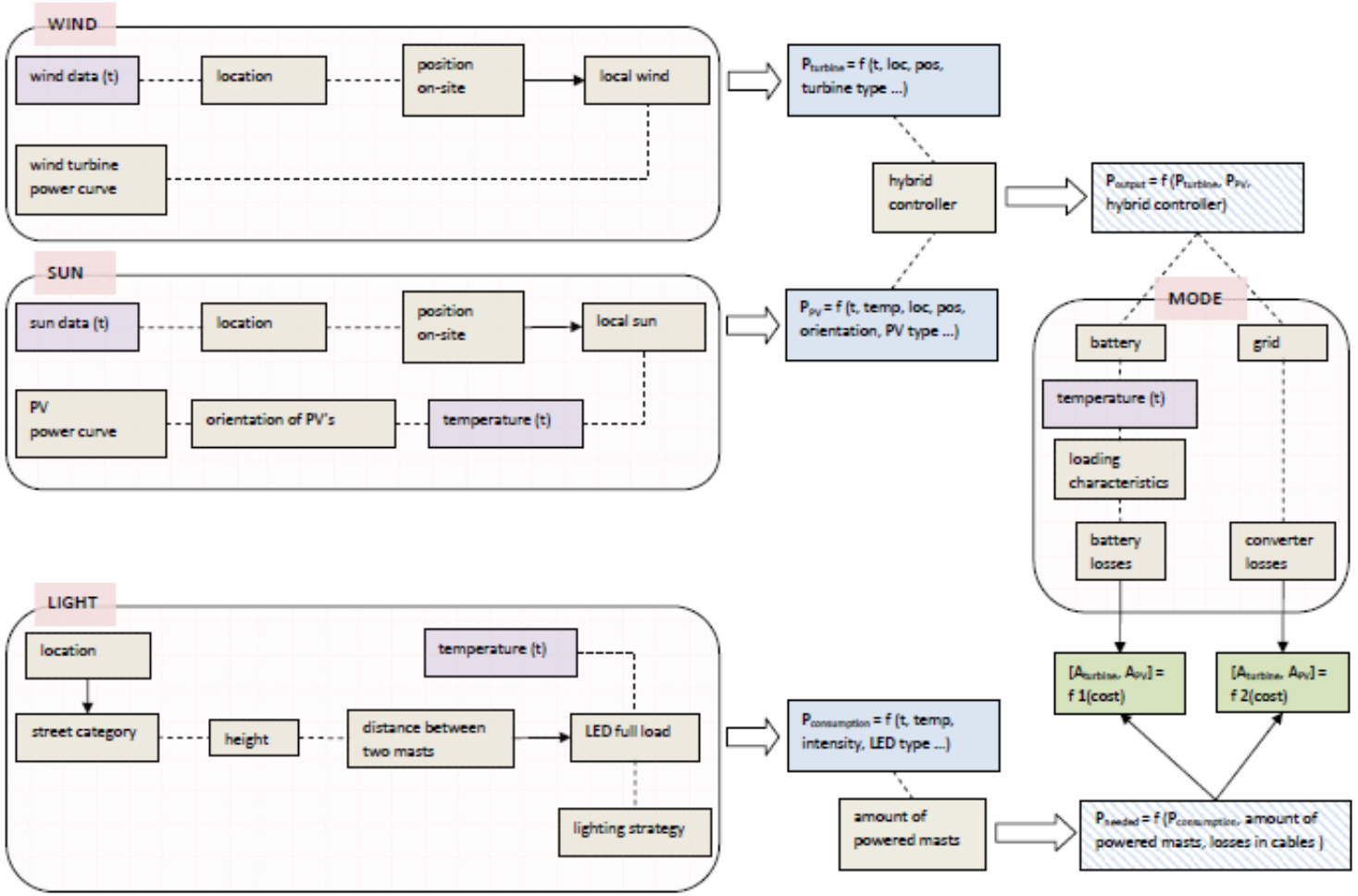
LED energy use

Battery tech.

Mathematical Model

Solar panel area, angle, orientation
Rotor area, placement, rotor type
Battery capacity

Mathematical model



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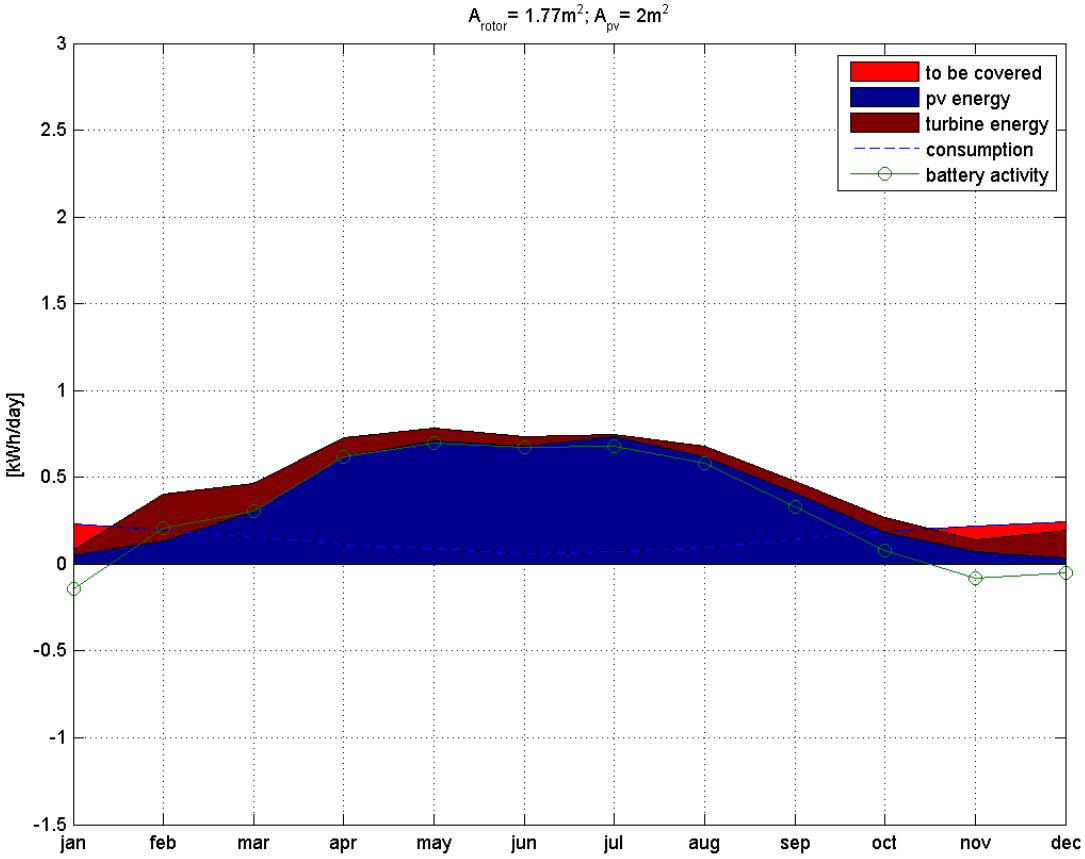
Energibalance - NHEOLIS



Street classes in Copenhagen

Red: ”Regional roads”
Dark blue: ”Distributuon streets”
Light blue: ”Larger city streets”
Orange: ”Pedestrian streets”
Dark gray: ”Local streets”

E2 Roads > 70%
2.5 lux

CopenHybrid vs internationalt state of the art

Test platform for hybrid systems

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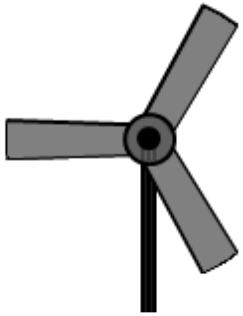

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DTU Energy Conversion
Department of Energy Conversion and Storage

Future work

- Wind energy optimization unit (generator starting at low torque, MPPT on electronics, gear)
- Optimization of solar cell unit (primarily electronics)
- Adjusting the LED unit and implementation of intelligent control
- Optimizing battery pack
- Optimizing the electronics
- Optimization of mathematical modeling system for the design of systems
- Optimization of mechanical engineering / design
  - Weatherability
  - Strength
  - Production

Conclusion

1. Can a hybrid system be developed full filling the needs of the Danish Municipalities?

   WELL – it seems possible!

2. Is there a business model?

   Maybe! ☺

   Labor cost -> high

   1000 $/m in Copenhagen cabling cost

   Solar panels cheaper than ever

   Small wind turbine maturing

   LEDs 2x efficiency in 2015

   Battery prices going down on e.g. LiFePo4

   Sensors/intelligence

3. International markets?

   Some commercial systems are already installed

- Thanks to ELFORSK PSO 343-021, funding
- Thank you for your attention

Internationally leading research

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Producers

PHILIPS sense and simplicity

PRIESS

Users

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